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ABSTRACT

This report presents an overview of the distribution formats for instructional television. While broadcast means of distribution have ben the mainstay of instructional television in the past, there are at least three television technologies that are considered as appropriate delivery mechanisms: over the air transmission, including broadcasting, instructional television fixed services, and satellites: wire or cable transmission, such as cable television and common carrier services: and copy technologies such as video tape, video cassette, video disc, facsimile, and print Braille. Each of these formats is discussed and considerations for their use for educational programming are presented. (Author/RAO)

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TELECOMMUNICATIONS STUDY COMMISSION

"TELEMEDIA TECHNOLOGY"

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INTRODUCTION

Over the past 25 years, public television stations have been the mainstay for instructional television for elementary and secondary education. There have also been occasional uses of ITV for off-campus college-level instructional programming. However, during the coming decades, the single broadcast channel of the public television station may not be sufficient by itself to meet instructional television (ITV) needs. ITV simply implies the use of video format for presentation of material.

A broad range of video communications technologies is now available for ITV program delivery. These technologies may be employed separately or in a wide variety of combinations. There is evidence that these technologies are in use in at least limited ways in the Commonwealth and for this reason, this paper will provide a brief description of the usage characteristics as they apply fundamentally to instructional television and, on a more broad level, to any program of telecommunications in the Commonwealth.

Video technology has grown vigorously since instructional television first made its appearance on the educational scene. Today, more than 80% of the Commonwealth population are served by public commercial broadcast television. Approximately, 20% of American households are served by the growing technologies of cable television and instructional television fixed services (ITFS) now in operation in many communities including some experiments in the Tidewater of Virginia. The video tape recorder when first introduced was an expensive, sensitive instrument most appropriate

to the broadcast engineer. Today, video cassettes can be operated by children and the price of the player is now within the reach of most school budgets. In fact, cassette recorders are not uncommon in the home.

While broadcast means of distribution have been the mainstay of ITV in the past, there are at least three television technologies that should be considered as appropriate delivery mechanisms:

1. over the air transmission; including broadcasting, ITFS and satellites
2. wire or cable transmission; such as cable television and common carrier services and
3. copy technologies; such as video tape, video cassettes and video discs, facsimile, print Braille[1]

Some combinations of modes are also possible where two or more mechanisms combine to create a discrete distribution system.

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[1]Strictly speaking, copy technologies are not delivery systems. Rather they are storage depositories that may record information for subsequent use by delivery systems which can be the US Postal Service telecommunications or hand-delivery methodologies.

OVER THE AIR TELECOMMUNICATIONS

Broadcasting

Television broadcasting in the public sector can trace its history to 1952 when the FCC allocated 70 channels above the VHF television band for public television broadcasting. These "ultra-high frequency" or UHF channels serve as the broadcast medium for more than 60% of public stations in the country and all of the PTV stations operating at the present time in Virginia.

By 1976, there were about 270 public television or non-commercial television stations operating in the country under five different classes of FCC licenses: community, school district, university, state and municipal. All of the Virginia licensees are community licensees. These licensees have an organizational relationship with the Public Broadcasting Service (PBS) and are interconnected through microwave and satellite means for distribution of the PBS programming schedule.

Interconnection is the mainstay of broadcasting, both commercial and educational, for through interconnection even the smallest station can receive high quality and often very expensive programming. ITV programming can be delivered, and is most often delivered, through the public television stations. Commercial broadcast stations also have this capacity and, especially in the early days of ITV, made significant contributions to the dissemination of instructional programming through their commercial broadcast capacities.

One of the most attractive features of broadcast technology for educational uses in the Commonwealth is its accessibility.

A majority of schools in the Commonwealth are within reach of a public broadcast facility. Another advantage of broadcasting is that it can be a relatively low cost delivery system for moving the educator's (or other State official's) message especially when there are large numbers of receiving sites within the stations coverage area. It is also relatively easy and economical to increase the number of receiving sites within a station's coverage area because no basic changes are required in the station itself or in its transmission systems.

But the restricted program capacity and the lack of flexibility in using broadcast programs have been major limitations on increasing the use of over the air methods of transmission in school systems. Typically, three major reasons for not making better use of broadcast technologies, if in fact the signal reaches a building, have been identified: lack of reviewing equipment, lack of appropriate programming, and scheduling difficulties.

The availability of a receiving set in the classroom has been a significant factor affecting the use or lack thereof of ITV programming in the school systems. If the teachers do not have easy access to a television set when they need it, the broadcast capacity is effectively wasted. The lack of appropriate programs is another shortcoming and is in part a function of limited air time and the fact that most public stations have only a one-channel broadcast capacity. The fixed time schedule of broadcast television which can be a problem even in elementary schools as well as

well as secondary schools also becomes a major barrier in the use of ITV, where departmentalized instruction is common.

Since public broadcasting usually provides only one channel for distribution, there is a definite limit to the number of hours of programming which can be distributed in a day. In Virginia, most of the school systems operate the ITV schedule between the hours of 9 a.m. and 3 p.m. This schedule limitation does not provide much room for flexibility. It is difficult to run multiple repeats of programs much less find time to respond to requests from individual schools or individual teachers.

These limitations on the use of broadcast for the delivery of ITV programs stem from this fact that it is a direct delivery system: programs are broadcast and used simultaneously. While this may not constitute a problem for, say, continuing education where the viewers are at the home, it does create problems for the in-school user. Scheduling difficulties which are caused by the direct delivery of broadcast signals can in some circumstances be overcome through the use of on-site delivery systems. For example, video tape recorders have been used in the Commonwealth at the school site to record programs off the air and play them back at a more convenient time to the teacher.

Instructional Television Fixed Services

ITFS is a type of over the air transmission system designed specifically for the delivery of instructional programs by schools,

governmental organizations or other non-profit education groups. Its advantage is that it can offer up to four channels of simultaneous transmission in comparision to the broadcasting's single channel capacity.

The Instructional Television Fixed Services (ITFS) was approved in 1963 by the FCC to provide a low power, high quality instructional televison service without the need of costly buildings, equipment and engineering personnel. Although the fidelity of the signal does not yet approach the degree of perfection available from the higher powered broadcasting systems, it is known that the medium provides the program quality essential for the effective delivery of curricula.

The FCC set aside the frequency band between 2500 and 2690 megahertzs to be divided into 31 (later 28) ITFS channels. There are four such channels to any one geographical area and each channel has a six megahertzs band width capable of carrying television signals conforming to the standard broadcast specifications. The technical characteristics of ITFS, however, and limitations imposed by the FCC are sufficiently different from broadcasting to differentiate these two broadcast techniques.

ITFS distribution is limited to relatively small distances. The maximum distance reached by ITFS signals is usually 20-25 miles (as compared to the 40-50 mile radius of a powerful public broadcasting station.) However, repeaters can be used to deliver to more distant sites. As with public broadcast, television, transmitting and receiving locations, ITFS stations must be within line-of-sight If line-of-sight transmitter-receiver relationships can't be established,

numerous repeaters are required, the economics of ITFS are significantly reduced.

The allocated frequency spectrum of ITFS may be used not only for video but also for voice and even data transmission and the upper portion of the allocated spectrum may be used for reverse transmission, that is response and/or inquiry in either video voice or digital form from the intended receiver. This two-way voice and video capacity is one of the three unique features of ITFS (privacy and multi-channel capacity are the others).

As an over the air transmission system, ITFS is subject to the same problems of frequency crowding and interference as other over the air systems. This disadvantage is alleviated to some extent, however, by its restricted geographical coverage.

The installation of ITFS systems represent a considerable capital output initially. The system was designed as a low cost alternative to broadcasting however but because it reaches such a limited area, these relatively low costs may be high when compared against the potential reception audience. Operation of the system once in place, however, is comparatively inexpensive. The principal costs are associated with the origination and distribution equipment. Since only a single receiving antenna and down converter per reception site are required to receive all four channels, the cost of reception equipment in the schools is relatively low.

Program signals in an ITFS system may be either copied material (especially video tapes) or real-time programming transmission (such as the programming which systems delivery engineering educational and/or inservice teacher training) usually use.

The most attractive features of ITFS from the standpoint of education are its multichannel delivery system and its interactive or two-way transmission capacity. Not only can a much larger volume of programming be transmitted over the four channels than is possible with the single broadcast channel capacity in many public stations but as many as four different programs can be run simultaneously. This allows much more flexibility in targeting programming to specific audiences.

A related advantage of ITFS stems from the fact that it is a closed system used exclusively for the delivery of ITV programs. Because ITFS is appropriate for small scale delivery systems, the time schedules of transmissions can be structured more appropriately to suit the time schedules of the individual teachers.

Like broadcasting, ITFS is a means of direct delivery meaning that the programs are transmitted and used simultaneously. The advantages and disadvantages identified for direct broadcasting also generally apply here with the exception that ITFS can offer both some sense of privacy and four simultaneous channels for transmission.

In addition to educational programming directed to the classroom, a liberal interpretation of usage rules by the FCC permits the sharing of ITFS systems with governmental or non-profit organizations for educational purposes. In-service training for specific skills such as medicine and nursing, safety programs and other continuing professional education are all candidates for ITFS delivery. While no such uses have been made of this technology in the Commonwealth

(with the exception of the special education teacher in-service program being offered by the ITFS facility under CenTeX, Inc. auspices in Tidewater) the potential for more broad use in these areas in the Commonwealth is definitely present.

In addition, when not in use for the delivery of educational programming, the system can also be used for the transmission of information relating to school administration. It is significant that shared facility may also mean shared cost. Educators and public station managers considering the possibility of ITFS licenses should do well to investigate the opportunities for shared use of this commodity.

Satellites

The use of satellites as relay stations has become commonplace within the past few years. The basic elements of a satellite system are the transmitter, the satellite vehicle itself, and the earth station antenna or dish. This means of over the air broadcast while new does not represent a fundamental change in technology to the ultimate user although financial considerations may have a bearing.

The principal advantage of satellite transmission is the ability to supplement land line facilities such as ground based microwave and cable. For many technologies, satellites can also reach into remote areas where it may be economically impractical to run conventional land transmission lines. The major disadvantage of this system is the high cost of ground stations and what the satellite communications engineers call the final mile problem.

As long as large and expensive ground stations are required, receiving dishes are likely to be located only in major installations such as a public broadcast station, the cable system head-end or possibly the ITFS transmitter. Since the receiving antennae are often located away from many receiving sites, the land line costs of interconnection of the central receiving earth station and, say, the school classroom can add significantly to the costs of operation of a satellite based transmission system.

Recent developments in the technology of satellite transmission and reception have reduced substantially the costs of both the earth stations up links and down links. Further economic reductions in these technology costs can presage an enhancement of use of satellite technologies both in the Commonwealth generally and instructional television specifically.

Satellite interconnection is now being implemented by the public broadcasting system. Several hundred earth stations are being located at or near public stations each with a capacity of receiving multiple television channels. It is possible also for some stations to both send and receive over the PBS satellite network.

The satellite itself performs the program distribution function. At the heart of the communications satellite is a device called a transponder. The transponder receives the up link, changes its frequency and redirects it earthward through the satellite's transmitting antenna. Satellites usually have a number of transponders, each capable of carrying one television

channel with audio support.

The transmission from the satellite back to earth is called the down link. The area covered by a satellite's down link is called its footprint. When used in a recent experiment, each of the two down links from one satellite have a footprint of approximately 300-500 miles for a total coverage area of approximately 30,000 square miles. If this is compared to the coverage of broadcasting or ITFS, it becomes clear that satellite technology is particularly appropriate used where wide area coverage is desired. In addition, topographical features have little impact on satellite transmission. Additionally, the satellite signal is usually a very high quality. Since receiving sites are approximately the same distance from the satellite, signal quality is also relatively uniform throughout the footprint.

Because specialized equipment is required to receive satellite down links, satellite delivery is essentially a closed system despite the fact that the down link could be constructed at any point within the coverage area. The two most attractive features of the satellite delivery are their coverage and channel capabilities. Satellites can reach a very large area with multiple channels. Satellite coverage is also relatively unaffected by topographical factors and can be used to interconnect non-contiguous areas. In addition, satellites provide two-way communication of both video and audio signals.

Perhaps the most significant disadvantage of the satellite technology is its newness and therefore the lack of familiarity with its technology by many existing professionals and its

present excessive cost. Technological advances, however, can be anticipated to reduce both of these disadvantages significantly in the not too distant future.

Satellites are, for example, now more cost-effective long distance delivery systems than are comparable land based cable and microwave networks. Thus, they will undoubtedly take over many functions currently performed by common carriers in the future in providing interconnection between national, regional, state and metropolitan delivery systems. From the point of view of education, the additional channels provided by satellites should permit increased distribution of ITV programming and other resources to local PTV, cable and ITFS stations.

CABLE TRANSMISSION SYSTEMS

Cable Television (CATV)

Community antenna television better known as CATV was originally developed to bring commercial television programming into remote or otherwise inaccessible areas that were unable to receive a satisfactory over the air signal. In 1948-49, the first cable television systems were constructed using strategically located high gain receiving antennae to pick up broadcast signals and a coaxial cable network to distribute the signal to each subscriber's television receiver.

For many years, the growth of cable systems was restricted both by the economics of the technology and by federal regulation to areas where the natural obstacles to signal reception were present. During the past decade, however, cable has become a

major new distribution system and has made significant inroads especially in the highly dense metropolitan areas.

Cable systems offer several distinct advantages over broadcasting. First, the use of a coaxial cable for distribution of signals greatly improves the quality of the picture received and eliminates much interference. In addition, the use of amplifiers in the distribution system allows for a substantial increase in the number of television channels that the system can distribute at a small per-channel incremental cost. This multiple channel capacity can be of great advantage to the community generally and to the educator for it provides a systems operator with the capability of originating his own programming or provide channels for other uses such as schools or colleges.

Until recently, the FCC has established the practice of allocating certain cable facilities for the use of the public benefit. They have been designated for use by educators, local government and for the public in the form of public access service. While rules concerning their number and availability have changed in the past several years, the principle of public service in cable systems has been firmly established.

Cable systems are "a local phenomenon." Because cables must use city streets, as rights of way, the systems are franchised by local governments. In exchange for the franchise, the cable system agrees to meet certain performance and construction standards. These standards can and often do include agreements to provide a cable connection at no cost to every public building in the franchised area in some cases including schools.

At the present time, the Commonwealth exercises no operational control or coordination over the installation of cable systems. Regulation is provided through the FCC and mainly through the franchise agreements negotiated individually and independently by each locality with each cable company doing business in its area.

Cable systems provide signals which can be received by standard television sets. This is generally accomplished by wiring the cable to the antenna connections. Up to 12 channels can be received using standard tune-in dial and additional channels can be added by providing the user with a special converter. Systems are in operation now that offer as many as 40, 60 or even 100 channels and known technology can significantly advance that capacity in the future.

The distribution network of coaxial cable used in CATV is similar to the cable used by the telephone company. Cables composed of optical fibers that carry light beams instead of electrical impulses are now being experimentally installed for this use in some cities. Cables of this type are capable of carrying literally hundreds of channels of video, voice and digital data and offer the user of the future an opportunity for diversity almost unimaginable by the standards of today's technology.

An important feature of cable systems is the potential for two-way communication. Indeed, the greatest educational value of cable may depend on this two-way interactive response between the teacher and the student.

Many other non-educational applications are also made possible through the introduction of this two-way transmission capacity.

For this reason, the FCC has decreed that two-way capability be included in new cable systems. This merely means that the system is capable of having hardware installed that provides this two-way capability. However, the cost of this additional hardware which could include minicomputer terminals and even small origination facilities at the receiving sites will likely have to be born by the user of this service.

Another advantage of the use of cables and the associated wiring of school buildings is the significant increase in program flexibility. Teachers in cabled schools have access to a variety of channels limited only by the cable system capacity and the school wiring budget. Cable systems provide educators with a system capable of a great deal of flexibility and diversity.

Leased Common Carrier Services

Another kind of cable transmission system similar to the cable system just described is a leased common carrier service available at rates established by state regulatory agencies and provided by common carriers. In 1971, the FCC created a new category of carrier referred to as specialized communications, common carriers. Services offered by these companies evolved out of the expanded use of computers and the need for high speed private lines for data transmission. Many of today's specialized common carriers can and do provide wide band or television services also.

The growing demand for long distance data transmission facilities has also resulted in licensing of many specialized

common carrier microwave distribution capabilities. Thus, today, for television purposes, these systems provide greater transmission alternatives for the ultimate user.

The advantages and disadvantages and many of the characteristics of the leased common carrier services parallel those of the cable television system just discussed. There are a number of advantages that common carrier communications systems can offer to designers and users of telecommunications systems. For example,

1. No capital investment is required for the communications or transmission portion of the system although fees are charged.

2. The time required to integrate the communications links into the system is usually much shorter than with the cable or privately owned network.

3. Sometimes operating monies may be available to the educational authorities rather than capital funds making this a much more feasible economic alternative.

There are, however, several disadvantages also.

1. Line rental charges are relatively high and are a continuing drain against school budgets.

2. While low and medium speed voice and data channels are readily available it is sometimes difficult to find a broad band or video channel available in a particular community and

3. Schools must be prepared and equipped to generate some of their own programming or enlist the aid of the public broadcaster to generate them since common carriers do not become involved generally in the content material being sent over their electronic highway.

Twenty years ago, virtually all television programs were presented live and except for the inadequate kinescope films that were made of syndicated shows there were no reruns. The advent of the video tape recorder in the late 1950s removed this limitation and opened up significant areas of technology of use for education, and perhaps other governmental, uses.

Video Tape

The basic concept of video tape recording is identical with that of audio recording familiar to most people. Visual information is converted into electrical currents to structure a magnetic coding on a strip of tape. The key difference between audio and video recording is the volume of the information to be stored per unit of time. The audio recorder stores signals with a band width of 20 kilohertzs while the video units store 200-300 times that quantity.

The recording system employed by professional television experts uses two inch wide video tape and is called a quadraplex system because it contains four recording heads. More recently, a second recording technique combining rotary or linear motion to produce a helical scanning pattern has been developed. These helical scan recording devices are less expensive than the quadraplex models and use a variety of tape widths. Thus, it is possible to use one inch , 3/4 or 1/2 inch wide video tape with correspondingly reduced purchase costs.

Some of these more recent recording techniques have resulted in a lack of standardization in video tape systems as well as some reduction in signal retention quality.

Within the past decade, video recorders suitable for home use have become available. These home recorders are relatively low cost and capable of playing back programs through a standard television receiver. The flexibility inherent in this kind of technology makes video tape recording an effective option for many educational uses as well as many governmental program problem solving situations.

Video Disc

Video disc is another play back device. The disc is a relatively recent development in program delivery systems. While not yet widely commercially available, the advent of video disc is still sufficiently imminent to be reviewed in the context of ITV copy technologies.

Video discs are thin plastic discs similar in appearance to an audio record. The video discs are rotated at very high speeds on a player which reads the information and sends broadcast quality signals to the antenna terminals of a standard television receiver (or direct video). Video disc technology has been developed independently by several concerns; hence, there is a potential problem here of system compatibility as is the case with video tape.

The use of video disc for education depends very much on the availability of desired programming produced in large enough quantity runs to make a read-only format attractive.

Two other factors present possible barriers to the use of video disc. Foremost is whether educators need to have access to a variety of educational materials. Some educators argue that classroom requirements call for access to diverse sources of material with greater flexibility than disc may allow. However, there are materials of such highly perceived value as to be useful to a very large number of educators and demand for this material may grow until high production runs and low delivery cost discs become possible.

The second factor inhibiting the adoption of video disc is the lack of industry standardization alluded to above.

Of all the distribution systems discussed thusfar, the copy systems offer the greatest flexibility for use in the delivery of ITV programs. Copy systems are not subject to the scheduling difficulties of broadcasting where a program can only be viewed when transmitted. The teacher can pick and choose from a catalog of programs. Because copies can be run on small portable equipment, the teacher can stop, start and replay material at will. And, it is not unrealistic to presume that students may, in the not too distant future, be able to take portable play back equipment home with them for study much as they now carry home books.

Copy systems also represent an excellent way to begin building an ITV delivery system. Florida, for example, has built its entire ITV distribution system on copied material bicycled to the

individual school districts on their request and in accordance with their perception of need.

Distribution costs for copy systems take the form of transportation expenses. It takes gasoline and time to move a truck along a street thus the longer the delivery path and the more of them in use, the greater the cost of this distribution methodology. A second limitation is logistical and administrative. Clearly, as the number and complexity of delivery paths increase so do administrative demands. Generally, the use of full-time shipper/receiver/coordinator staff is required in any significant copy technology transmission system.

Copy technologies also imply the need for a program library of tapes or discs at some central facility. The major difficulty with program libraries is that a relatively large number of shelf copies must be maintained in order to serve users. These copies also run the risk of early obsolescence making the need for continual update and continual expense to replace and increase the shelf supply. Bicycling systems are in place in Virginia in the limited extent to serve the school needs. (Bicycling is a term used to describe a method of distributing material by circulating a single program copy to a number of different users in a regular sequence.) It is a distribution method that has been used by school systems.

The successful use of bicycling systems and copy technology depends upon careful scheduling and considerable self discipline

on the part of users. Bicycling is a copy distribution system offering a maximum of flexibility and although requiring careful pre-planning and schedule coordination. It may also require experienced technicians to maintain and supervise the system since tapes are relatively fragile and require careful handling and storing.

Of course, copy technologies also include a variety of audio-only technologies. The record, tape recorder and audio cassette are common technologies widely used in school, home and office. They need only be mentioned here as additional useful copy technologies.

Facsimile transmission systems are also in use in a variety of government, safety, medical and educational programs where hard copy transmissions (especially signatures and graphics) are important. Facsimile teletypewriters, teltext (i.e., televised transmission of textual matter only) and a variety of adaptations, including Braille messages, all have place in any discussion of telemedia technology.

Each of the systems and techniques described above should be included in any discussion of telecommunications in the Commonwealth of Virginia. The use and application of these technologies in Virginia today, and their possible application to solving program delivery problems in the Commonwealth, will be discussed in other Working Papers.

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